STATUS OF DUST CONTROL TECHNOLOGY ON U.S. LONGWALLS

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ABSTRACT

Longwall mining is the most productive method of underground coal mining in the United States (U.S.), and record levels of production have been reached in recent years. These ever-improving production levels have the potential to generate significantly higher quantities of respirable dust. Consequently, the longwall industry continues to struggle with controlling dust liberation and maintaining compliance with the federally-mandated respirable dust standard. In response, longwall operators have increased the application of primary dust controls, airflow and water flow, in an effort to improve respirable dust control and reduce worker exposure.

Pittsburgh Research Center (PRC) personnel conducted dust surveys at 13 longwalls operating throughout the U.S. and collected information to: identify current operating practices on these longwalls, identify the types of dust controls in use, document the levels at which these controls are being applied, and measure the respirable dust levels present. This data was analyzed to quantify the dust levels generated by the major sources on the longwall section and to evaluate the relative effectiveness of the control technologies in use.

INTRODUCTION

Improvements in longwall equipment and mining practices have paved the way for the increases in production and productivity and longwall mining now accounts for over 40% of the coal produced underground in the U.S. The power made available to the shearer has increased by 90% in the past decade, while power to the face conveyor has more than doubled (Anon., 1995). These increases have allowed for faster mining and larger longwall panels. From 1984 to 1993, the average width and length of longwall panels have increased by 39% and 21%, respectively, so that the average size of the panel was over 230 m (750 ft) wide and nearly 2135 m (7000 ft) long in 1994 (Anon., 1995). Longwall productivity has increased from an average of 1.4 metric tons per worker hour in 1983 to an average of 3.0 tons per worker hour in 1993. Average shift production has increased from 890 tons per shift in 1980 to approximately 3,250 tons per shift in 1994.

Unfortunately, higher production levels generate greater quantities of respirable dust (Webster et al., 1990). Historically, longwall mining operations have had difficulty in maintaining compliance with federal dust standards and in the early 1980s, 31% of the longwall designated occupation (DO) samples collected by the Mine Safety and Health Administration (MSHA) exceeded the respirable dust standard (Niewiadomski and Jankowski, 1993). Longwalls continue to experience difficulty in maintaining compliance. For fiscal year 1994, 20% of MSHA-collected DO samples exceeded the respirable dust standard and the percentage of longwall operations in noncompliance two or more times exceeded 21% (Niewiadomski, 1996). Twenty-seven percent of longwall shearer operator samples collected by mine operators between 1988 and 1992 for compliance sampling exceed the 2.0 mg/m^3 respirable dust standard (Anon., 1995a). In an effort to combat higher levels of dust generation, application levels for dust controls continue to be increased by longwall operators.

PRC initiated a surveillance effort to quantify the levels of dust being generated by the various sources found on today's longwalls, identify the types of control technologies in use, and quantify the levels of application for these control technologies. Respirable dust surveys were completed at longwall mining operations located in Alabama, Colorado, Illinois, Pennsylvania, Utah and West Virginia to collect data representative of conditions found among different mining regions.

SAMPLING METHODOLOGY

Gravimetric dust samplers operating at 2 L/min with a 10-mm nylon cyclone preseparator were utilized with stationary and mobile sampling strategies to quantify the levels of respirable dust generated by the major sources on the longwalls. The reported gravimetric concentrations were calculated for actual sampling time, which was a maximum of six hours, and not converted to Mining Research Establishment (MRE) equivalent dust levels. The sampling data generated from this survey can not be utilized for or compared to dust concentrations of compliance samples which are eight-hour, portal-to-portal samples.

Instantaneous dust measurements were used to augment the gravimetric sampling, particularly where short sampling durations precluded the collection of suitable mass with gravimetric samplers. Instantaneous measurements were obtained with the Real-time Aerosol Monitor (RAM), which displayed real-time dust measurements on an LCD readout and stored these measurements in a data logger for later analysis.

Fixed Point Sampling

Gravimetric dust samplers were located at the fixed sampling locations illustrated in Figure 1. The intake samplers (I) were typically located in the last open crosscut and used to isolate the dust contamination from sources outby the longwall face. If the mine was utilizing the belt entry as an additional intake, gravimetric samplers were located outby the last open crosscut and the stage loader to monitor dust levels liberated in the belt entry (B). The headgate samplers (H) were placed at approximately shield 10 and were used to monitor the dust concentration of the air coming onto the face. The difference between dust levels measured at H and the outby locations (I, B) would be dust generation attributed to the stage loader-crusher dust source. The tailgate samplers (T) were placed approximately 10 shields from the tailgate end of the face and used to provide an indication of the total dust generation along the face.

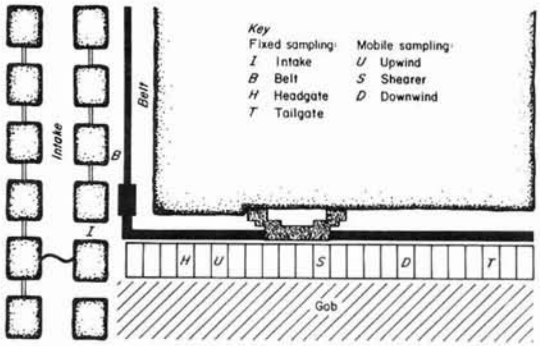

Figure 1. Dust sampling locations for longwall surveys.

At each of these sampling locations, at least 2 gravimetric samplers were located adjacent to one another and operated over the same sampling period. At these fixed sampling locations, samplers were typically started shortly after arrival upon the longwall face and operated continuously until sampling was completed.

Mobile Sampling

Mobile dust sampling was conducted by three sampling team members at locations shown in Figure 1 to determine the amount of dust generated by the shearer. Each of the team members maintained their relative position with the shearer as it moved across the face. The upwind samplers (U) were approximately 7.6 m (25 ft) upwind of the headgate drum and measured the intake dust levels reaching the shearer. The downwind shearer samples (D) were collected approximately 15.2 m (50 ft) downwind of the tailgate shearer drum. The difference between the dust concentrations measured at D and U was attributed to dust generated by the shearer. The samples collected at the tailgate end of the shearer (S) provide an indication of the dust migration from the face into the walkway.

At these mobile sampling locations, 4 gravimetric filters were worn by each team member. Two of the filters were used to measure dust levels during the head-to-tail pass, while the other two filters measured dust levels for the tail-to-head pass. The gravimetric pumps were turned off during extended down times so that the measured dust concentrations represent dust levels during mining.

Mobile sampling was also conducted to isolate the respirable dust liberated during shield movement on the head-to-tail passes. One team member was positioned approximately 7.6 m (25 ft) outby all shield movement while a second team member remained approximately 7.6 m inby all shield movement. Each team member carried a RAM and noted the beginning and ending time of the dust measurements. The average concentrations for these sampling periods were calculated and the difference between the outby and inby concentrations was attributed to dust liberated during shield movement.

Control Parameter Monitoring

Dust control parameters such as airflow, water flow and water pressure were measured. Vane anemometers were used to collect spot velocity readings at 10-shield intervals along the face during each sampling shift. Water flow meters were installed in the water line supplying the shearer sprays and periodic measurements of total water flow to the shearer were obtained. Hand-held pressure gages were used to measure the nozzle operating pressure on the shearer drum and external sprays.

MINING CONDITIONS AND CONTROLS

A variety of operating conditions were encountered in sampling the different mines throughout the country. Table 1 summarizes the parameters that were observed or measured during the individual mine visits. Five of the mines were utilizing a bidirectional cutting sequence, seven mines were taking unidirectional cuts and one mine was using a half-face cutting sequence. Average face width was found to be 220 m (720 ft) with an average mining height of 2.3 m (7.7 ft). Since many variations in face widths, mining heights, cutting sequences, web depths and tram speeds were observed, a tons per minute (tpm) calculation was made for the cutting passes to facilitate relative productivity comparisons between mines. As shown in Table 1, nearly a three-fold difference in tpm was observed. The lowest level was found to be 11.9 tpm for Mine A, while the highest level was found to be 35.4 tpm at Mine C. Therefore, Mine C has the potential to produce three times more dust than Mine A, if uniform dust-generation is assumed. Obviously, the physical characteristics of the coal seam, the depth of cut, the type and maintenance of the cutting bits, and dust controls being applied will have major impacts on actual dust generation.

Airflow and water application remain the primary dust controls and Figure 2 summarizes the data collected for these parameters. The average air velocity calculated from the spot velocity readings taken on the longwall faces was 2.5 m/s (497 fpm), with measured values ranging from 1.0 to 7.6 m/s (193 to 1500 fpm). The average velocity on the face of the surveyed longwalls represents an increase of over 0.5 m/s (100 fpm) when compared to the average air velocity data reported in a 1983 Bureau of Mines study (Jankowski and Organiscak, 1983). Past research (Jankowski et al., 1993) has indicated that air velocities greater than 2.0 m/s (400 fpm) should be utilized for improved dust control. Utilizing a rough estimate of the area under the shields for each face, an average air quantity of 19.2 m3/s (40,700 cfm) was calculated. The maximum air quantity observed was 50.0 m^3/s (106,000 cfm). This data shows that on average, longwall operators are applying more air on longwall faces than ever before.

Likewise, the use of water has greatly increased in an effort to control higher levels of dust liberation. Average water usage at the shearer was found to be 379 Lpm (100 gpm) at an average drum spray pressure of 965 kPa (140 psi). In the 1983 Bureau study, average water flow to the shearer was found to be 238 Lpm (63 gpm) at a drum spray pressure of approximately 414 kPa (60 psi). Previous research (O' Green et al., 1994) has indicated that drum spray pressures above 690 kPa (100 psi) can aggravate shearer operator dust exposure by forcing dust into the walkway. Recommended operating pressure for nozzles in shearer drums is between 480 and 690 kPa (70 and 100 psi). Only 3 of the 13 longwalls surveyed had drum spray pressure in the recommended range, with nine operations having pressures that are above the recommended range. This control parameter is one of the most important parameters when considering shearer operator dust exposure and is relatively easy to control. The preferred method of reducing nozzle pressure would be to select a larger orifice di-

Table 1. Summary of longwall parameters

Mine	Face width m (ft)	Cutting sequence	Cutting height m (ft)	Metric tons/ minute cutting	Face air flow V m/sec (fpm)	Face air flow Q m^3/sec (cfm)	Shearer water L/min (gpm)	Drum pressure kPa (psi)
A	259 (850)	Unidi- T-H cut	2.0 (6.5)	11.9 T-H	7.6 (1500)	50.0 (106000)	435 (115)	552 (80)
B	183 (600)	Bidi-	1.8 (6.0)	13.9 T-H 11.0 H-T	1.9 (377)	10.9 (23000)	284 (75)	1379 (200)
C	192 (630)	Unidi- T-H cut	3.4 (11.0)	35.4 T-H	1.8 (354)	28.3 (60000)	379 (100)	1207 (175)
D	244 (800)	Half-face*	2.7 (9.0)	21.7*	1.5 (285)	11.3 (24000)	303 (80)	827 (120)
E	229 (750)	Unidi- T-H cut	3.1 (10.0)	23.1 T-H	1.9 (375)	21.2 (45000)	360 (95)	2068 (300)
F	244 (800)	Unidi- T-H cut	2.1 (7.0)	11.3 T-H	3.7 (723)	30.2 (64000)	265 (70)	1379 (200)
G	259 (850)	Half-web Bidi-	2.7 (9.0)	32.9 T-H 28.2 H-T	2.5 (490)	20.3 (43000)	454 (120)	862 (125)
H	253 (830)	Bidi-	1.8 (6.0)	19.1 T-H 23.0 H-T	3.0 (594)	17.5 (37000)	341 (90)	931 (135)
I	282 (925)	Bidi-	1.7 (5.5)	27.6 T-H 20.7 H-T	2.3 (443)	11.3 (24000)	379 (100)	965 (140)
J	152 (500)	Unidi- H-T cut	2.4 (8.0)	31.5 H-T	1.0 (193)	7.6 (16000)	568 (150)	862 (125)
K	183 (600)	Unidi- H-T cut	2.1 (6.8)	18.9 H-T	1.5 (294)	10.9 (23000)	303 (80)	172 (25)
L	198 (650)	Unidi- H-T cut	2.7 (9.0)	26.6 H-T	2.7 (530)	23.1 (49000)	447 (118)	689 (100)
M	175 (575)	Bidi-	1.7 (5.5)	12.7 T-H 15.9 H-T	1.6 (308)	7.1 (15000)	379 (100)	689 (100)

* Headgate to Shield 60 cleanup, Shield 60 to Tailgate cut; Tailgate to Shield 60 cleanup, Shield 60 to Headgate cut.

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ameter in the spray nozzles to increase flow and reduce pressure. A pressure regulator could be installed in the water supply line to the drums if greater reductions in pressure are needed.

Nearly all of the shearers were equipped with an air-moving, shearer-clearer type of external spray system on the body of the machine. This spray system is designed to confine dust generated at the shearer drums near the face so that the ventilating air can carry the dust away from the shearer operators before the dust migrates into the walkway. All of the shearers were also equipped with radio remote control units, which should allow the shearer operators to position themselves in areas protected by the shearer clearer sprays. However, the tailgate shearer operator on most of the longwalls would routinely travel downwind of the tailgate drum to observe the roof horizon during head-to-tail cutting passes or the floor horizon during tail-to-head passes. By positioning himself two to three shields downwind of the tailgate drum, the tailgate operator would typically increase his exposure to higher concentration dust clouds. At several operations, the tailgate operator would further complicate his dust exposure by lagging a greater distance behind the shearer to help the jack setter(s) advance shields.

DUST CONTROL EFFECTIVENESS

Table 2 summarizes the dust sampling results for both the stationary and mobile gravimetric sampling locations.

Dust generation attributed to shield movement is also included in Table 2. The minimum, average and maximum dust levels from the stationary sampling locations and from shield movement are illustrated in Figure 3.

The dust concentrations shown in Figure 3 indicate that mixed levels of success are being achieved for the mines sur-

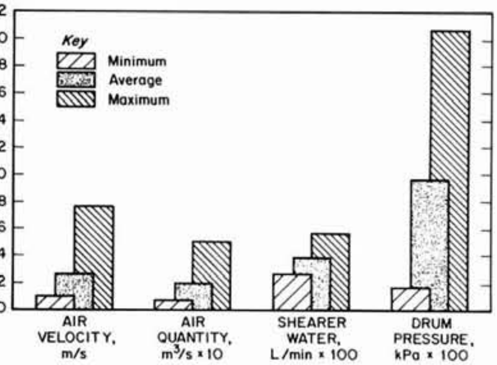

Figure 2. Range of primary dust control parameters measured during surveys.

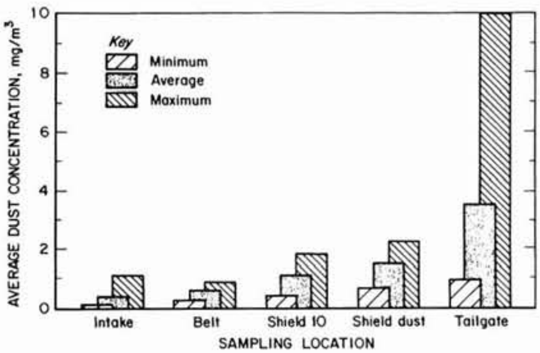

Figure 3. Range of dust concentrators measured at stationary sampling locations and for shield advance.

veyed. Comparison between the minimum and maximum dust levels at the intake sampling location shows over a ten-fold increase in respirable dust levels measured at different mines. Two of the longwalls had very low intake entry dust of approximately 0.1 mg/m³, while one operation had a very contaminated intake level of 1.1 mg/m³. The remaining operations had intake levels between 0.3 and 0.6 mg/m³. At both of the mines with the low intake levels, the intake entries were very wet with standing water at various locations along the entries so that minimal dust was generated by equipment travel.

Six of the longwalls were utilizing the belt entry to bring intake air to the longwall face. In these operations, the dust liberated in the belt entry would be carried to the face and could add to face dust levels. For the six longwalls utilizing belt air, the average dust level in the belt entry just outby the stage loader was found to be 0.6 mg/m³, while the average intake concentration in these mines was 0.5 mg/m³. On average, the belt entry has the potential to add to face dust levels. However, this increase in intake dust levels appears to be negated by the potential for increased dilution that can be obtained with additional air brought up the belt entry (Potts and Jankowski, 1992). The average air quantity found on the face for the mines utilizing belt air was 26.0 m³/s (55,000 cfm). For the other seven mines, the average air quantity on the face was 13.2 m3/s (28,000 cfm). At the mines utilizing the belt entry as an intake, the additional quantity of air available on the face would negate the average 0.1 mg/m³ increase in dust generated in the belt entries.

The dust levels measured at shield 10 represent the concentration of the intake air coming onto the face and would include contamination from the outby sources in the intake, the belt and stage loader-crusher generated dust. The average concentration observed at shield 10 was 1.1 mg/m³ which is a relatively high quantity because it represents 55% of the 2.0 mg/m³ dust standard. The difference between the intake/belt concentration and the concentration measured at shield 10 would primarily be dust generated by the stage loader-crusher unit. On average, this difference was found to be 0.7 mg/m³ and indicates that improvements in stage loader-crusher dust control should be pursued. At a minimum, the stage loader-crusher unit should be properly enclosed with belting or steel plate to prohibit dust escape and water sprays should be installed to reduce dust liberation. Belting or brattice can also be installed at the crusher inlet and stage loader to belt transfer to reduce dust liberation. Additional dust control can be achieved with water-powered scrubbers, fan-powered scrubbers or foaming agent added to the spray water.

Tailgate dust levels exhibited a wide range of values with over a ten-fold difference between the minimum and maximum dust levels observed. The lowest observed dust level at the tailgate was from the face that had the highest air quantity, while the longwall with the highest tailgate dust level had the lowest quantity of ventilating air on the face. Tailgate dust levels for 9 of the 13 longwalls were grouped in a relatively narrow band between 2 and 4 mg/m³.

As shown in Table 2, the dust levels at the tailgate location can be substantially lower than the dust levels measured at the downwind shearer mobile sampling location. The mobile sampling primarily represents dust generated during active mining, while the tailgate concentrations include all down time. In addition, high concentration dust clouds generated at a source (i.e. shearer) can become diluted as the cloud mixes with the ventilating air as the cloud disperses along the face.

Mobile sampling was conducted on the head-to-tail pass so that shield generated dust could be isolated from dust liberated by the shearer. In two mines, shields were advanced downwind of the shearer during the tail-to-head pass so that no shield dust measurements were made at these mines. Average dust generation attributed to shield movement was found to be 1.5 mg/m³. A relatively clear-cut division in shield generated dust was observed. Five of the mines had shield dust levels below 1.2 mg/m³, with an average concentration of 1.0 mg/m³. The shield dust concentrations from the other six mines were all above 1.8 mg/m³, with an average concentration of 2.0 mg/m³. Four of the five mines with low shield dust were located in the eastern U.S., while five of the six with high shield dust were located in the west. Previous research (Organiscak et al., 1985) had indicated that those mining operations that leave coal at the roof typically generate higher quantities of shield dust than those operations leaving only rock at the roof. Dust results from these longwall surveys support

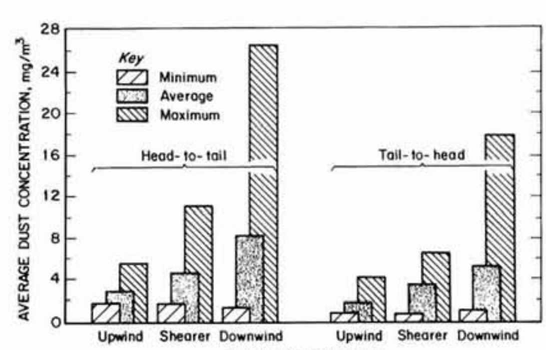

Figure 4. Summary of mobile sampling results for cutting passes.

Table 2. Summary of average gravimetric dust concentrations from longwall surveys

Mine	Intake	Belt	Shield 10	Shield dust	Upwind shearer H - T	Upwind shearer T - H	Shearer H - T	Shearer T - H	Downwind shearer H - T	Downwind shearer T - H	Tailgate
A	0.24	0.25	0.54	0.90	1.43	0.77	0.70	0.69	2.23	1.05	0.96
B	0.25	n/a	0.93	1.20	2.55	2.30	2.77	5.31	3.94	4.45	1.72
C	0.35	0.46	1.39	2.05	3.43	3.95	3.42	3.52	8.93	6.96	3.27
D	0.25	n/a	1.07	1.80	2.25	1.76	2.36	3.17	3.72	2.69	2.05
E	0.30	n/a	1.35	n/a	2.20	1.60	2.80	4.35	2.95	4.85	2.70
F	0.33	0.52	1.21	n/a	0.98	1.48	2.83	2.98	3.55	4.71	3.7
G	0.37	n/a	0.79	1.0	1.84	0.86	2.50	1.34	2.94	1.79	3.16
H	0.35	0.63	1.76	1.02	2.70	3.05	2.93	3.30	5.35	2.90	3.51
I	0.07	n/a	0.42	0.67	1.73	1.03	2.29	2.54	4.17	2.61	2.16
J	1.10	0.88	1.81	2.26	2.87	2.29	7.27	5.47	26.55	6.07	5.64
K	0.62	n/a	0.96	1.80	5.54	4.31	5.35	4.60	7.97	4.67	2.91
L	0.59	0.80	1.18	2.19	2.19	1.78	3.64	7.20	3.36	10.38	3.91
M	0.08	n/a	0.98	1.87	3.45	1.73	11.07	6.46	18.57	17.84	10.04

this trend in that the mines in the west were operating in high coal seams and typically left some coal at the roof. In the eastern mines no coal was left at the roof.

Figure 4 summarizes mobile dust sampling results for the cutting passes. All of the dust levels displayed (minimum, average, maximum) for each of the sampling locations were higher for the head-to-tail passes. When cutting in the head-to-tail direction, the headgate drum is cutting along the floor in an exposed position where the ventilating air can readily pass over the drum. When cutting from tail-to-head, the headgate drum is shielded from the ventilating air by the coal face, which makes it more difficult for the dust to be entrained in the airstream. Dust levels at the upwind location for the head-to-tail passes are higher than for the tail-to-head direction and include dust generated by shield movement upwind of the shearer.

Figure 5 summarizes mobile sampling results for the cleaning passes. In general, the head-to-tail passes had lower dust concentrations than the tail-to-head passes. These dust levels

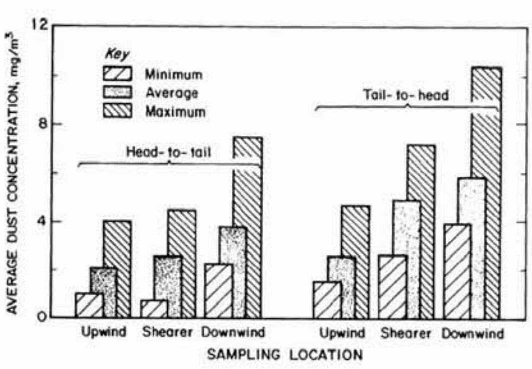

Figure 5. Summary of mobile sampling results for cleaning passes.

may once again reflect the shielding of the shearer drums from the face airflow. For the head-to-tail passes, the cowls on the shearer would shield the drums from the face airflow, but on the tail-to-head passes, the drums would be exposed directly to the airflow.

The difference between dust levels immediately upwind and downwind of a dust source was dust generation attributed to that source. For example, the difference between the downwind and upwind shearer sampling locations was used to calculate the dust generated by the shearer. Calculation of the dust contributions from the intake, stage loader/crusher, shield advance and the shearer for each mine was completed and results are listed in Table 3. The dust contribution from each of these sources was weighted based upon pass times calculated from time study data collected at each mine. For example, if the head-to-tail passes at a mine accounted for 60% of the total cycle time for a complete pass across the face, the dust levels generated by the shearer during the head-to-tail pass would receive a 60% weighting. The dust levels generated on the tail-to-head pass would receive a 40% weighting. If shields were advanced during the head-to-tail pass, shield dust would also receive a 60% weighting.

Figure 6 illustrates the average contribution from each of the sources for the mines surveyed. The shearer remains the largest source of dust on the longwall and accounts for over half of all dust generation during mining. At mines J and M, the shearer produced over 82% of the dust on the longwall face. At both of these mines, the downwind dust levels were much higher than for the other 11 mines and at each mine, the shearer cut a substantial amount of rock along the face. In addition, these mines had the lowest quantity of ventilating air on the face.

Shield movement and the stage loader/crusher units can also generate substantial quantities of dust. With the higher production levels found on today's longwalls, the need to advance a larger number of shields during a given shift has increased and

Table 3. Contributions during mining from major longwall dust sources

Mine	Dust source contribution, %			
	Intake	Stage loader	Shields	Shearer
A	17.4	20.8	27.1	34.7
B	6.5	17.6	31.1	44.8
C	6.2	14.9	19.4	59.5
D	7.6	24.9	30.1	37.4
F	8.2	15.2	16.9	59.7
G	13.2	14.9	35.6	36.3
H	12.3	32.0	25.7	30.0
I	2.2	11.1	21.2	65.5
J	5.5	4.6	7.0	82.9
K	16.6	9.1	30.0	44.3
L	10.9	7.5	21.8	59.8
M	0.4	4.9	10.1	84.6
Avg	8.9	14.8	23.0	53.3

thus increased the potential dust exposure from this source. Similarly, with more coal and rock being processed through the stage loader and crusher during a given shift, the quantity of dust liberated at this source can also be significant. On average, shield advance accounted for 23% of the dust-make, while the stage loader/crusher contributed nearly 15%.

SUMMARY

PRC conducted dust surveys on numerous longwall operations in the early 1980s to document what types of control technologies were being used and quantify the dust generated by the major sources on the longwall. Significant changes to the longwall equipment and operating practices have been implemented since this survey and average shift production is now over 3.5 times higher than in 1980. Consequently, longwall operators are attempting to control higher levels of respirable dust generation and continue to have difficulty in maintaining compliance with the respirable dust standard. In response, mine operators have substantially increased the levels of the dust control parameters that are applied on longwalls. PRC personnel recently completed dust surveys on 13 longwall operations to evaluate the dust levels being generated on these longwalls and the types and effectiveness of the control technology in use.

The use of ventilating air and spray water are the primary means used by longwall operators to control dust generation and worker exposure. Average air flow on the face was found to be 2.5 m/s (500 fpm) with an estimated air quantity of 19.2 m3/s (40,000 cfm). This average air velocity represents an increase of 0.5 m/s (100 fpm) over the average level observed in a Bureau of Mines survey of longwalls in the early 1980s. However, 7 of the 13 mines surveyed had air velocities below 2.0 m/s (400 fpm)

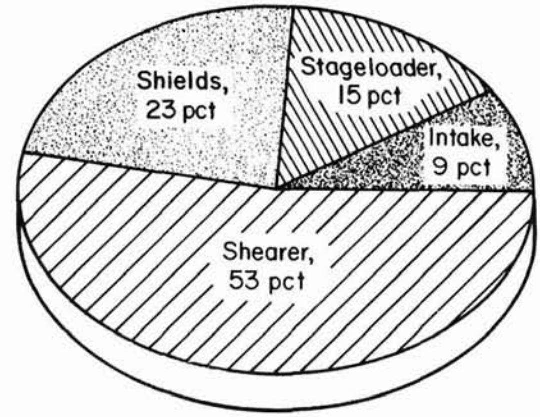

Figure 6. Average dust contribution of major dust sources on longwall faces.

which has been suggested as a minimum recommended velocity in previous publications. Six of the mines surveyed were utilizing the belt entry as an additional entry to carry intake air to the face. The average quantity of air found on the face in those mines utilizing belt air was nearly twice as high as those mines that didn't. Four of these mines had average face air velocities that were over 2.7 m/s (525 fpm). Dust levels measured in the belt entry were found to be nearly equal to the average dust level in the main intake entry, which indicates that a positive influence on face dust levels would be realized in those mines using the belt as an additional intake entry.

All but one longwall had water spray systems on the shearer that were based upon the principles of the shearer clearer spray system. This spray system is designed to prevent shearer generated dust from reaching the walkway in the area around the shearer. Longwall operators are also applying larger quantities of water at the shearer in an effort to control respirable dust. Average water flow to the shearer was found to be 379 Lpm (100 gpm), which represents and increase of nearly 150 Lpm (40 gpm) over levels applied in the early 1980s. Operating pressure at the shearer drum sprays was found to vary greatly between the mines that were surveyed with a minimum pressure of 172 kPa (25 psi) and a maximum of 2070 kPa (300 psi). Only 3 of the 13 mines were operating in the range of 265 to 690 kPa (70 to 100 psi) which was shown by previous research to minimize dust liberation. The majority of the measured drum pressures were well above 690 kPa (100 psi) which increases the potential for the drum sprays to force dust from the face into the walkway.

The average level of dust generated during mining by the intake, stage loader/crusher, shield advance and shearer were calculated. The shearer continues to be the most significant source of respirable dust generation on longwall faces and accounts for over 50% of the dust generation on the faces. Comparison of dust levels measured during cutting passes shows that dust levels for head-to-tail cuts were higher than those measured for tail-to-head cuts. During clean-up, dust levels were higher on the tail-to-head passes. Higher dust levels on the head-to-tail cuts and tail-to-head clean-ups may be resulting from the shearer drums being more directly exposed to the ventilating air. Consequently, in those mining operations utilizing unidirectional cutting sequences, dust liberation may be minimized if cutting was completed in the tail-to-head direction.

Dust generated during shield movement was found to contribute an average of 23% to the total respirable dust on the face.

The shield-dust results support earlier research which indicated that greater levels of respirable dust are generated during shield advance if coal is left at the roof. Four of the five mines with shield dust levels below 1.2 mg/m^3 were operating in mining heights less than 2.0 m (6.5 ft), and none of these mines were leaving coal at the roof. Five of the six mines with shield dust levels above 1.8 mg/m^3 were operating with mining heights greater than 2.1 m (6.8 ft) and typically left several inches of roof coal.

The stage loader/crusher is another potentially significant source of respirable dust and accounted for approximately 15% of the average dust generation on the longwall. Most of the mines surveyed had enclosed crushers and stage loaders with water sprays operated inside the enclosed units. However, a few operations had stage loader/crusher units that were not adequately enclosed and dust contributions from the stage loader/crusher accounted for over 25% of the dust measured on the longwall at these mines.

The primary means of controlling dust levels on longwall faces is achieved by using water sprays in an effort to reduce the amount of respirable dust that is liberated and supplying ventilating air to dilute and remove airborne respirable dust. Results from these surveys suggest that ventilating air and spray water both must be properly applied to minimize worker dust exposure on high production longwall faces.

REFERENCES

Anonymous, 1995, Longwall Mining, Energy Information Administration, DOE/EIA-TR-0588, 60 pp.

Anonymous, 1995a, Criteria for a Recommended Standard: Occupational Exposure to Respirable Coal Mine Dust, National Institute of Occupational Safety and Health, DHHS (NIOSH) No. 95-106, 336 pp.

Jankowski, R.A., and Organiscak, J.A., 1983, Dust Sources and Controls on the Six U.S. Longwalls Having the Most Difficulty Complying with Dust Standards, U.S.Bureau of Mines IC 8957, 19 pp.

Jankowski, R.A., Jayaraman, N.I., and Potts, J.D., 1993, Update on Ventilation for Longwall Mine Dust Control, U.S. Bureau of Mines IC 9366, 11 pp.

Niewiadomski, G.E., and Jankowski, R. A., 1993,"Longwall Dust Trends and Developments in Longwall Dust Controls", Proceedings of the Sixth U.S. Mine Ventilation Symposium, Salt Lake City, Utah, pp 551-556.

Niewiadomski, G.E., 1996, Mine Safety and Health Administration, private communication.

O'Green, J.E., McNider, T.E., Gallick, J.M., Jarrett, R.J., and Jankowski, R.A., 1994, An Overview of General Operating Experience as It Relates to Longwall Dust Control. Proceedings of Longwall USA, Pittsburgh,Pennsylvania, pp.221-233.

Organiscak, J.A., Listak, J.M., and Jankowski, R.A.,1985, Factors Affecting Respirable Dust GenerationFrom Longwall Roof Supports. U.S. Bureau of Mines IC9019, 19 pp.

Potts, J.D., and Jankowski, R. A., 1992, Dust Considerations When Using Belt Entry Air to VentilateWork Areas, U.S. Bureau of Mines RI 9426, 12 pp.

Webster, J.B., Chiaretta, C.W., and Behling, J., 1990,Dust Control in High Productivity Mines, SME Annual Meeting, Preprint 90-82, Salt Lake City, Utah, 9 pp.